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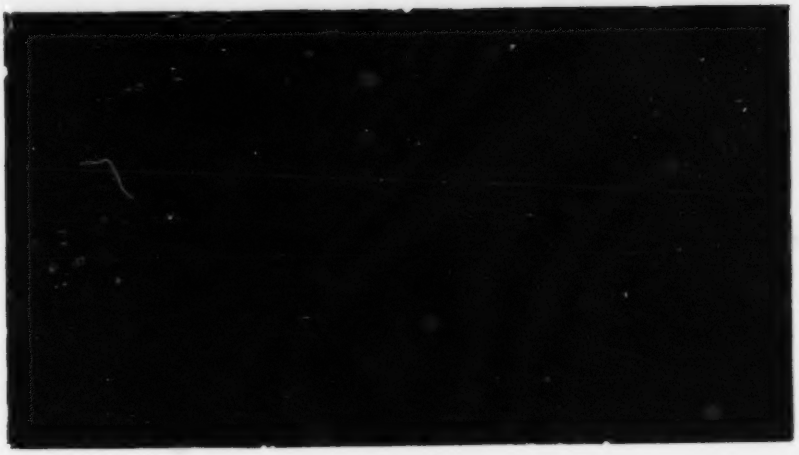

RESEARCH DIVISION

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To: Dr. D. Mills
Director of Research

SOME NOTABLE ACCOMPLISHMENTS (1984-88)

Report No. 89-89-K

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ABSTRACT

A list of high-benefit projects which reached technical completion in the years 1984 to 1988 has been compiled. These have been divided into the three categories, "Realized Benefits", "Expected Benefits" and "Benefits Difficult to Quantify".

Realization of the benefits from the first two categories is virtually certain. The net benefits over project costs in these categories total 650 M$. This number was calculated from a few projects for which the benefits were relatively easy to quantify. It represents only a small fraction of the total benefits generated by the Research Division in this period. The gross cost of operating the Division over the same time period was about 305 M$.

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To Dr. D. Mills
Director of Research

SOME NOTABLE ACCOMPLISHMENTS (1984-88)

W.G. Hanson and B.C. Jeppesen

1. INTRODUCTION

A report (Number A84-463) documenting some notable accomplishments in the Research Division for the years 1979 - 1983 was issued in 1984. The present report is similar in format but covers the years 1984 to 1988.

The projects have been divided into three categories depending on the fraction of the benefit that has been realized and the difficulty in quantifying it. It is interesting to note that net benefits of the projects in the two categories "Realized Benefits" and "Expected Benefits" totalled 650 M$. This number was calculated from a few projects for which the benefits were relatively easy to quantify and for which the realization of these benefits was virtually certain. It represents only a small fraction of the total benefits generated by the Research Division in this period.

The gross cost of operating the Research Division over the same period was about 305 M$.

2. RESULTS

Projects listed in this report have reached technical completion between December 1983 and December 1988 and have expected or realized net benefits of at least one million dollars or substantial non-monetary benefits as outlined more fully in Appendix A. Twenty-seven projects satisfying these criteria are listed in Appendix B. The benefits and costs shown there are the results of cash flow analyses carried out in accordance with guidelines set forth in the Corporate Financial Evaluation Manual.

All dollar figures are in terms of December 1988 dollars. The term "research spending", "Research Division spending" and "research costs" all have been used to indicate money that was spent by the Research Division regardless of the source of funding. The order in which the projects have been listed has been purposely randomized to avoid any spurious interpretations of ranking.

A summary of the projects with quantifiable monetary benefits is shown at the end of this section in Tables 1 and 2. All of the quantified benefits reported have been confirmed with the client at least in order of magnitude.

Table 1 contains projects in which the benefits have been categorized as "Realized". The benefits in this category have either been fully or largely realized by Hydro with any remaining benefits expected in the near future. Table 2 contains projects with benefits that

have been categorized as "Expected". This category contains projects for which, at the very least, there is substantial commitment to implementation. In many cases implementation is complete and some of the benefits have been realized.

Table 3 at the end of this section lists several projects with benefits categorized as "Difficult to Quantify". Some of these have safety or environmental protection as their chief benefit. Some have obviously large monetary benefits which are nonetheless difficult to quantify. The projects listed in this category are a representative rather than a complete set. A large body of work on environmental protection and on hazard elimination has been excluded simply because of the volume involved, as have several projects with monetary benefits that are undeniable but difficult to estimate.

In spite of the difficulties in fully assessing the benefits of the research work carried out in this time period a very conservative lower limit can be obtained by looking at the sum of the net benefits from the two categories in which the monetary benefits are both quantifiable and virtually certain. The categories are "Realized Benefits" and "Expected Benefits". The sum of net benefits over project costs in these categories is 650 M$.

TABLE 1

PROJECTS WITH REALIZED BENEFITS

(Total Benefits in this Category are 462.7 M$

Project Title	Benefit M$	Full Description on Page*
Probablistic Uprating of Middleport TS	5.3	B5
Large Scale Fuel Channel Replacement	89.0	B10
Repositioning of Garter Springs before Commissioning	359.0	B12
Pressure Tube Inspection	8.4	B16
Very Low Temperature Concrete	1.0	B17

*This refers to page number in Appendix B

TABLE 2

PROJECTS WITH EXPECTED BENEFITS

(Total Benefits in this Category are 187.7 M$)

Project Title	Benefit M$	Full Description on Page*
Transient Stability Excitation	13.0	B8
Channel Inspection and Gauging Apparatus for Reactors	60.0	B9
Spacer Location and Repositioning	100.0	B14
Reduced Gadolinium Poisoning of Moderator	10.0	B15
Lightning Location Network	2.1	B18
Arced Gas Analyzer	2.6	B20

*This refers to page number in Appendix B

TABLE 3

PROJECTS WITH BENEFITS DIFFICULT TO QUANTIFY

Project Title	Full Description on Page*
Residential Hot Water Use Patterns	B4
Separable Insulated Connector Tool	B6
Current Limiting Arrester Disconnector	B7
Calandria Tube Removal	B11
Fish Impingement Control	B13
Innovative Heat Pump Technology	B19
Fall Protection Development	B21
Porcelain Insulator Failure Mechanism	B22
Investigation of Portable Gas Detectors	B23
Burner Assisted Heat Pump	B24
Containment Leak Location	B25
Fault Arc Diverter	B26
Industrial Customer Assistance	B27

*This refers to page number in Appendix B

3. SUMMARY AND CONCLUSION

A list of high-benefit projects which reached technical completion in the years 1984 to 1988 has been compiled and demonstrates the worth of research results produced during those years. The quantifiable net monetary benefits from these, attributable to the Research Division contribution, totals 650 M$. This figure does not include the benefits from the many projects carried out in that time period with net benefits of less than one million dollars each. The gross cost of operating the Research Division over the same time period was about 305 M$.

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APPENDIX A

NOTABLE ACCOMPLISHMENT CRITERIA

NOTABLE ACCOMPLISHMENTS LIST

SELECTION CRITERIA

1. The technical part of the project should have been completed within the five year period between December 1983 and December 1988.

2a. The realized or projected net benefits should be of the order of one million dollars or greater and the benefit to cost ratio should be greater than two.

OR

2b. There should be substantial benefits of a kind which are difficult to quantify. These include but are not limited to corporate citizenship, pollution abatement, improved safety and technological advances.

APPENDIX B

NOTABLE ACCOMPLISHMENTS LIST
(Project Descriptions)

In the project descriptions listed here the benefits and costs quoted are the result of cash-flow analyses carried out in accordance with guidelines set forth in the Corporate Financial Evaluation Manual and are in dollars of December 1988. The terms, "research spending", "Research Division spending", and "research costs" all have been used to indicate money that was spent by the Research Division regardless of the source of funding.

The order in which the projects are listed has been purposely randomized to avoid any spurious interpretations of ranking. To facilitate reference an index is provided on the next page. The page numbers associated with each project title provided convenient project identifiers and are used as such in the tables in the main body of this report.

PROJECT INDEX

Title	Page
Residential Hot Water Use Patterns	B-4
Probabilistic Uprating of Middleport TS	B-5
Separable Insulated Connector Tool	B-6
Current Limiting Arrester Disconnector	B-7
Transient Stability Excitation Control	B-8
Channel Inspection and Gauging Apparatus for Reactors - CIGAR	B-9
Large Scale Fuel Channel Replacement	B-10
Calandria Tube Removal	B-11
Repositioning of Garter Springs before Commissioning	B-12
Fish Impingement Control	B-13
Spacer Location and Repositioning	B-14
Reduced Gadolinium Poisoning of Moderator	B-15
Pressure Tube Inspection	B-16
Very Low Temperature Concrete	B-17
Lightning Location Network	B-18
Innovative Heat-Pump Technology	B-19
Arced Gas Analyzer	B-20
Fall Protection Development	B-21
Porcelain Insulator Failure Mechanism	B-22
Investigation of Portable Gas Detectors	B-23
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Industrial Customer Assistance	B-27

RESIDENTIAL HOT WATER USE PATTERNS
(Benefit Difficult to Quantify)

Research Result

Comprehensive hot water use patterns have been developed based on over sixty "household-years" of field monitoring. Data of this quality did not previously exist. It has been incorporated in the American Society of Heating, Refrigerating and Air-Conditioning Engineers (ASHRAE) handbook (1987 HVAC - Systems and Applications).

Background

Data was gathered on hot water usage for a one year time span (1982-83) in fifty homes located throughout Ontario. An additional five houses in Toronto were monitored for a two year span (1981-83). Water use readings were taken at fifteen minute intervals. These readings along with the demographic information on the households monitored formed the data base from which a variety of usage patterns were developed. These reflect weekday-weekend differences, seasonal variations and, the influence of several demographic factors.

The project was cofunded by ASHRAE and Ontario Hydro.

Benefit

This study has significantly extended the level of knowledge in the subject. The results have been used by ASHRAE in the revision of its handbooks. They have also been used by the U.S. National Bureau of Standards, the U.S. Department of Energy, the Canadian Standards Association and other research organizations in the development of new testing and evaluation criteria for water heating equipment.

Though the benefit to those involved in the design of future water heating systems should be substantial it is nevertheless difficult to quantify.

PROBABILISTIC UPRATING OF MIDDLEPORT TS
(Realized Benefit)

Research Result

Sophisticated probabilistic techniques have been developed and used to establish short-circuit current capabilities of the existing strain bus installation at Middleport TS. Application of these techniques combined with personnel safety assessment and cost alternatives evaluation led to an optimal uprating decision. This resulted in savings of millions of dollars in comparison with a conventional deterministic uprating procedure.

Background

Middleport TS interfaces with two major generating stations and several major transformer stations. A conventional deterministic analysis of fault current trends indicated the need for a major uprating for which the cost would have been about 11 M$. A task force made up of personnel from D&D Generation, D&D Transmission, PSOD, Transmission Operations, the System Planning Division, and the Research Division applied probabilistic techniques to the analysis. The study indicated that only very limited uprating is required, costing about 14 k$. The study cost about 500 k$ and resulted in savings of 11 M$ through the avoidance of an extensive uprating. The net present value of the benefit is therefore 10.5 M$. A collaborative effort among several divisions was involved and it is not possible to accurately assign credit. The Research Division was responsible for a major share of the analysis and for the purposes of this report half of the benefit will be allocated to it.

Cost and Benefits

The research cost for this work has a present value of 500 k$ while the net present value of the benefit is 10.5 M$. The share of the benefits (see section above) allocated the Research Division is 5.3 M$.

SEPARABLE INSULATED CONNECTOR TOOL
(Benefit Difficult to Quantify)

Research Result

Though separable insulated connector systems are an integral part of underground distribution systems, no satisfactory, safe and reliable tool to allow connector switching has been available. Recently, such a tool has been developed by the Research Division. It became available for use in the summer of 1988.

Background

Underground distribution became common in the late 1960's. By 1978, problems with switching loadbreak connectors in these systems reached the point where utilities were reluctant to operate separable connectors at all. This resulted in inefficient operating procedures and reduced system reliability. Attempts by the manufacturers of separable connectors to improve connector materials, and attempts by tool manufacturers to develop better connector switching tools were unsuccessful.

In 1984 work was initiated in the Research Division to address separable connector switching difficulties through advanced, ergonomically engineered tools. The resulting device has a simple latching and release mechanism which firmly grasps the connector to assure control during switching. It also incorporates a specially designed impact hammer which functions without the operator changing grip and which provides impact forces without reducing connector control. After being positively evaluated from a human factors point of view by the Health and Safety Division and after being successfully field tested for over a year this device became available to Ontario Hydro staff in 1988.

Benefit

The benefits of this project include enhancing the safety of linemen, the avoidance or reduction of distribution system power outages, and the re-establishment of viable, full capability underground distribution systems. The North American market for these devices outside of Ontario Hydro is expected to be substantial.

Though the benefits of this project are sizable they are difficult to quantify. They relate largely to safety and to the restoration of distribution system operating capabilities which had been eroded by poor connector system performance.

CURRENT LIMITING ARRESTER DISCONNECTOR (CLAD)
(Benefit Difficult to Quantify)

Research Result

An arrester disconnector with superior properties has been developed at the Research Division. Commercialization is expected in the near future.

Background

Conventional distribution-class surge arresters can under certain failure conditions explode into shrapnel-like shards of porcelain. Both utility workers and members of the public are put at risk in such situations. In the late 70's concern over this problem led to work on new designs, some of which are now commercially available. These rely mostly on a heavier body which reduces the explosion risks but still poses a hazard to linemen in the vicinity both from the end caps being blown off and from a highly mobile fault arc. An alternative device developed in the Research Division interrupts the fault current in the failing arrester and effectively eliminates hazard by greatly reducing the energy in the fault arc. An additional advantage of this device is that it is possible to retrofit existing installations.

The development of this device was financed partially by the CEA and partially by Ontario Hydro. Several prototypes have been tested in the laboratory with very satisfactory results.

Benefit

Though a number of manufacturers are currently considering the commercialization of this device the monetary benefits from this are difficult to estimate in advance. Other benefits are illustrated in the comparative table below.

	Old Style Arrester	Heavy-Body Arrester	CLAD
Hazard to Public	Considerable	Significantly Reduced	Eliminated
Hazard to Linemen	Great	Somewhat Reduced	Eliminated
Retrofitting		Not Possible	Easily Done
System Outage at Failure	Inevitable	Inevitable	Avoided

TRANSIENT STABILITY EXCITATION CONTROL
(Expected Benefit)

Research Result

A Transient Stability Excitation Control (TSEC) device which reduces power system instability problems following a major disturbance has been developed and installed on all Bruce NGSA, Bruce NGSB and Nanticoke TGS generating units. The extra margin of safety provided permits increased loading on the transmission system.

Background

Use of this device provides some compensation for the inadequacies in certain parts of the transmission system. Following a severe disturbance with major transmission lines heavily loaded, the system tends to accelerate and go out of synchronism with neighbouring utilities. To counteract this action, the TSEC controller detects the disturbance and momentarily increases the generator terminal voltage. This causes an increase in generator power output and thereby reduces the acceleration of the generators and thus contributes to system stability.

The present value of the development costs of TSEC is 184 k$ while that of the installation costs is 430 k$. Assuming that adequate transmission capacity from Bruce GS will be available five years after TSEC installation and making very conservative estimates of the additional transmission available during those five years due to the use of the TSEC device gives a net present value of benefits of 26 M$.

This project involved a collaborative effort between the Research Division and the System Planning Division. It would not be meaningful to attempt to accurately assign responsibility for the benefits. Purely for the sake of quantification one-half of the total benefits mentioned in this section is used in the "Costs and Benefits" section below.

Costs and Benefits

The costs of developing, building and testing the necessary hardware has a present value of 184 k$. The net present value of the share of benefits allocated to the Research Division (see above) is 13 M$.

CHANNEL INSPECTION AND GAUGING APPARATUS FOR REACTORS - CIGAR
(Expected Benefit)

Research Result

A sophisticated channel inspection device has been successfully used in an active reactor. The design and development of this device took place largely in the Research Division.

Background

Since 1975 work has been underway in the Research Division on an automated device to remotely inspect the fuel channels of a CANDU reactor. The device developed uses ultrasonic beams, eddy current techniques and accelerometer readings. It is capable of detecting pressure-tube flaws and of measuring the diameter and wall thickness of pressure tubes and their sag. As well, it can determine the separation between the pressure tube and the calandria tube and locate the spacers. Field use of this device was successfully begun with an inspection of Bruce Unit 2, in September of 1985.

The Design and Development Division-Generation which is the client group for this project have estimated the benefits to be in the order of 125 M$. This is based on avoided radiation dosage and avoided reactor down time. An additional benefit is the superior quality and quantity of diagnostic information available in comparison with any alternative.

Several groups were involved in the development of this device. These include Design and Development-Generation, Atomic Energy of Canada Limited and Canadian General Electric as well as the Research Division. Though it is not possible to accurately assign credit in a collaborative effort, for the sake of being quantitative, half of the total benefit has been allocated to the Research Division in the section below.

Costs and Benefits

The present value of Research Division spending on this project is 4.4 M$ while the net present value of the share of projected benefits allocated to the Research Division (see above), is about 60 M$.

LARGE SCALE FUEL CHANNEL REPLACEMENT
(Realized Benefit)

Research Result

A method developed in the Research Division has been used in the retubing operation at Pickering units 1 and 2. The method involves the use of induction heating to separate the pressure tubes from their end fittings.

Background

Some development work was done on this technique from 1977 to 1982 in preparation for the scheduled retubing of Pickering A. After the G16 pressure tube rupture in August of 1983 at unit 2, development was accelerated and the technique was proven in field conditions in mid 1984. Loosening of the end-fitting roll joints was completed on Pickering unit 1 in 1985 and on Pickering unit 2 early in 1986.

There are several advantages over the alternative method of cutting and milling. These include saving one end fitting from each tube, reducing the manpower required, and reducing the man-rem exposure. A benefit study carried out by the client indicated a minimum saving to the Corporation of 60 M$ with the figure being possibly as high as 120 M$. The median figure of 90 M$ has been used in the section below.

The benefits reported above are calculated only for the retubing program at Pickering units 1 and 2 and do not include the considerable benefits which will accrue during future large scale retubings.

Costs and Benefits

The present value of the research costs is 774 k$. The net present value of the benefit is 89 M$. This yields a net benefit to cost ratio of 115.

CALANDRIA TUBE REMOVAL
(Benefit Difficult to Quantify)

Research Result

A method involving induction heating for the separation of calandria tube rolled joints was developed in the Research Division and was available for immediate use when the G16 calandria tube removal became necessary at Pickering unit 2 in 1983. With some modification to accommodate a different geometry it was available again in 1986 for the removal of the N06 calandria tube in Bruce A unit 2.

Background

Work was begun early in 1983 on developing a method of removing a calandria tube without damage to the tube sheet. This work was requested and funded by the Design and Development Division (Generation) and was intended for use on tube J15 of Pickering unit 4. In August of 1983 when it became necessary to remove the G16 calandria tube at Pickering unit 2 the method was ready and was successfully used.

Subsequent to the rupture of the N06 pressure tube and calandria tube in Bruce unit 2 in March of 1986 the method was again used for calandria tube removal. Modifications were made to accommodate the different geometry of the Bruce reactor. Additional challenges were present in this case due to the presence of a circumferential crack on the east end rolled joint insert and of longitudinal cracks on both ends of the calandria tube. The calandria tube was successfully removed by the use of this technique in May of 1986.

Benefit

Both for P2G16 and B2N06 the alternative method of calandria tube removal would have been milling. This would have required more time and may well have resulted in damage to the tube sheets. The availability of the induction heating method made rapid action possible and minimized an adverse public perception. The availability of this method for use in possible future situations when calandria tube removal is necessary provides a measure of security difficult to put in monetary terms.

REPOSITIONING OF GARTER SPRINGS BEFORE COMMISSIONING
(Realized Benefit)

Research Result

Following the failure of the G16 tube in Pickering unit 2 it was realized that the garter springs in five units not yet commissioned should be repositioned. A technique developed in the Research Division successfully accomplished this.

Background

The G16 pressure tube in Pickering unit 2 ruptured in August of 1983. It was determined that contact between the pressure tube and calandria tube had been instrumental in this failure.

Garter springs occupy the annulus between the pressure tube and the calandria tube and act as spacers reducing the probability of contact between the tubes. The G16 event highlighted the importance of proper positioning of the springs. It was decided to reposition the springs in Bruce units 5, 6, and 7 and Pickering units 7 and 8 before these units were commissioned.

A technique developed in the Research Division involving the use of a magnetic impulse was used. Work on the repositioning started in January of 1984 and was completed early in 1985.

The alternative would have been to re-tube these units. This would have involved the cost of re-tubing as well as an extended delay in commissioning and the use of replacement power from less economic fossil units. It would have also resulted in an adverse public perception.

Costs and Benefits

The present value of research and development costs for this project is 1.3 M$ while the present value of benefits is 360 M$. This gives a net present value of benefits of 359 M$ and a benefit to cost ratio of 276.

FISH IMPINGEMENT CONTROL
(Benefit Difficult to Quantify)

Research Result

Research Division expertise in impingement prevention has resulted in several improvements in the environmental interface. These include a new intake design at Darlington GS, a unique rope-barrier system at Bruce GS 'B', the installation of a hidrostal pump for controlling eels at Saunders GS and the use of sonic devices at Lambton GS. These are examples of a large number of incidents in which fish-behaviour expertise made it possible to meet the requirements for a water intake license or solved an existing operational problem.

Background

The Research Division is actively involved in the investigation of several aspects of fish behavior as part of a continuing program of developing and demonstrating state-of-the-art impingement control devices. These investigations include fish responses to light of various wavelengths, fish responses to several sound generation devices, fish pump effectiveness and porous veneer intake effectiveness.

Among the sound generation devices are a fishdrone which transmits sound of selected frequencies into the water and a mechanical impact device which creates repetitive sharp sounds of low fundamental frequency and high amplitude. Work with these has led to the characterization of various fish species according to their sonic-amplitude and frequency sensitivity.

The world class quality of the program is evidenced by the large amounts of external funding it has attracted. The accumulated knowledge of fish behavior makes it possible to respond rapidly and effectively to problems in the aquatic environment as they occur.

Benefits

Though the benefits of this project are large they are difficult to quantify. They include meeting licensing requirements and reducing plant downtime due to impingement. Perhaps most important is the part this work plays in ensuring that Hydro's operations are environmentally benign.

SPACER LOCATION AND REPOSITIONING (SLAR)
(Expected Benefit)

Research Result

An alternating current device which can reposition garter springs in a commissioned reactor has been developed in the Research Division and is scheduled for use in 1989.

Background

The failure of the G16 pressure tube in Pickering unit 2 highlighted the importance of garter spring position. Because of the presence of moderator and the additional safety requirements, the impulse technique used on units before commissioning is unsuitable for use on commissioned reactors.

A superior technique using an alternating current device working on the principle of a linear induction motor has been developed in the Research Division. It was successfully field tested in April of 1986. A number of these devices have been built and tested in preparation for their use as production tools. The repositioning program in which they will play the key role is expected to begin in 1989.

Costs and Benefits

The present value of research and development costs of this device is 1 M$ while the net present value of the benefits of avoiding the retubing of the four reactor units currently committed to this program is in excess of 600 M$. A very conservative estimate of the benefit due to the Research Division involvement is 100 M$.

REDUCED GADOLINIUM POISONING OF MODERATOR
(Expected Benefit)

Research Result

Between October 1982 and March 1985, a number of negative reactor power transients occurred at Pickering NGS-B. These resulted in a loss of power production. Investigations undertaken by the Research Division in consultation with Central Nuclear Services, the Design and Development Division (Generation) and Pickering NGS Operations, determined the cause of the problem and established corrective procedures to prevent future occurrences.

Background

Investigations were undertaken to determine the cause of lost production and reactor trips at Pickering NGS-B. Gadolinium was found to have formed a loosely-held precipitate in ion exchange columns. During a slurry transfer, the gadolinium was returned to the moderator causing reduced reactivity and power loss. Research established that use of a cation resin over a mixed bed would reduce the formation of gadolinium precipitate and bounds for the mixing ratio of cation resin to anion resin were determined. New quality assurance procedures have been instituted by Supply Division and resin slurry procedures have been amended by Operations. The incidence of these reactive problems has now dropped to near zero. Recommendations based on this work have been issued to other nuclear stations.

The cost of power loss from PNGS-B has been determined to be in excess of 2 M$ in 1985 alone. Had this problem been allowed to continue the present value of power loss over a ten year period from 1986 to 1996 would have exceeded 20 M$. The solution of this problem involved a collaborative effort. Half of the benefit can be attributed to the Research Division contribution.

Costs and Benefits

The cost of the research into the problem and into establishing corrective procedures has a present value of 162 k$. The net present value of the benefit attributable to the Research Division is 10 M$. This results in a benefit to cost ratio of about 60.

PRESSURE TUBE INSPECTION
(Realized Benefit)

Research Result

A high frequency ultrasonic testing method was developed to enhance the ability to detect defects in pressure tubes.

Background

The manufacturing defect that resulted in the failure of Bruce Unit 2 pressure tube N6, in 1986, was not detectable by conventional techniques. A high frequency (70 to 100 MHz) ultrasonic method, developed in the Research Division, readily detected the defect. It was decided that the offcut rings from pressure tubes in all reactors should be inspected with this new method as well as with conventional ultrasonic methods to look for defects that may have been missed during manufacturing inspection. An automated test system was developed and operations personnel were trained in its use. Further, a decision was made to upgrade the inspection of pressure tubes at the manufacturing stage. This method was used to inspect all Darlington unit 4 pressure tubes.

This inspection technique and its implementation has mitigated Atomic Energy Control Board (AECB) concerns about the possibility of other defective tubes residing in operating reactors. Specifically, 410 fewer rolled joint inspections were required by the AECB, saving 20 days of reactor down time.

Costs and Benefits

The present value of the research and development costs is 56 k$. The net present value of the benefit achieved from the one incident noted above is 8.4 M$. This gives a net benefit to cost ratio of 150.

The savings associated with the upgraded inspection at the manufacturing stage can also be assumed to be significant. Because of the difficulty in quantifying this savings it is not included in the benefits claimed above.

VERY LOW TEMPERATURE CONCRETE
(Realized Benefit)

Research Result

A new polymer concrete that does not require special precautions in cold weather has been developed jointly by the Research Division and Cappar Ltd., Brampton, Ontario. The new concrete was evaluated by Research Division and approved for use in the construction of a transmission line from Sudbury to Elliot Lake.

Background

In Northern Ontario, the frozen ground makes road access easier, thus winter is the best time to carry out foundation work. However, winter conditions cause serious problems in the placement of concrete bearing pads for transmission towers since normal Portland cement concrete will not develop strength under cold temperatures unless troublesome and time-consuming precautions are taken. Rock surfaces have to be preheated for 24 hours, then when the placement is completed, the pad has to be covered and kept heated for three days.

The development of very low temperature concrete means that work crews can leave remote areas as soon as the placement is complete. The necessity of spending extra days on site while the concrete cures is avoided. Replacement of deteriorating tower pads on live transmission lines in remote areas can now be carried out in a single working day. This is a saving of one to two days over the previous method and eliminates the necessity of power interruptions on the tower line.

In 1986 this concrete was used in the installation of a line from Sudbury to Elliot Lake. Because of its use the line was completed six months ahead of schedule resulting in a savings of about 2 M$.

A collaborative effort was involved in this project. An accurate allocation of responsibility for benefits is not possible. For the sake of quantification one half of the benefits mentioned in this section is being allocated to the Research Division in the section below.

Costs and Benefits

The present value of the research and development costs of the new concrete is 150 k$. The net present value of the share of the benefit allocated to the Research Division for the Sudbury to Elliot Lake line alone is 1 M$.

Further use of this material will greatly increase the benefits as future transmission lines are built and as well through its use in the repair of deteriorated concrete pads.

LIGHTNING LOCATION NETWORK
(Expected Benefit)

Research Result

Ontario Hydro has extended the Ontario LLP - Lightning Location and Protection System and tailored the output to its own system requirements. The Research Division has assisted with the selection of appropriate sites and the installation of equipment. Lightning data is fed into the Severe Weather Forecast and Detection System (SWORD). The result is an improved efficiency of the existing SWORD system with a consequent reduction of replacement energy required due to storm limits.

Background

Severe weather can cause substantial damage to Ontario Hydro's bulk electricity system (BES) and result in a bottling up of energy. The ability to detect high risk areas during severe weather allows the System Control Centre to make informed decisions regarding the most efficient distribution of output and to decide whether or not the power supply should be supplemented by other sources.

The Research Division has helped the Power System Operations Division (PSOD) by undertaking a project involving choosing sites and determining the method of installation of an advanced lightning detection system. This lightning data is fed into a PSOD meteorological monitoring system which automatically monitors all weather data available. Further installations being made will complete the coverage of Eastern Ontario by the end of 1989. Substantial savings have already been achieved through the reduction in replacement generation required for storm limits. More savings are anticipated from future installations. The net present value of benefits achieved and projected from 1985 to 1995 is 4.2 M$.

This project was a collaborative effort with personnel from PSOD. An exact allocation of credit for the results is meaningless but for the sake of quantification one half of the benefits is being attributed to the Research Division in the section below.

Costs and Benefits

The present value of the research and development costs is 0.8 M$. The net present value of the benefit attributed to the Research Division's participation is 2.1 M$ (see section above).

INNOVATIVE HEAT-PUMP TECHNOLOGY
(Benefit Difficult to Quantify)

Research Result

An innovative heat pump/heat recovery system was designed by the Research Division and installed in a Toronto restaurant. An energy saving of 42% in water heating and air conditioning was realized as well as a power demand reduction of 44%. The project demonstrated that heat-pump technology can be applied to motels, laundromats, gymnasiums and other commercial establishments to save energy and reduce operating costs. Ontario Hydro is investigating the possibility of using this technology in its Orangeville Conference and Development Centre.

Background

This research project was initiated by Ontario Hydro for the Canadian Electrical Association to demonstrate the capabilities of advanced heat pump technology in commercial establishments for process applications. The design of the system is unique in that it takes advantage of waste heat production, hot water demand and space cooling needs. By properly balancing the hot water storage, heat pump capacity and utilization of the cool discharge air, through a specially designed distribution duct, significant energy savings and demand reduction were achieved as noted above. In the demonstration installation the heat pump water heater was installed in the kitchen near the ceiling with the air intake facing the ovens and cooking area. This supplied the best source of waste heat while providing space to connect the distribution duct to the cool air discharge. The air duct is fitted with adjustable vents and a damper, allowing a cool air flow of 800 litres a second to be distributed in the kitchen area and maintaining a comfortable working environment. Excess cool air is directed to the basement where the main refrigerator compressors, the office and a storage area are located. This eliminates the need for separate air conditioning equipment.

The American Society of Heating, Refrigeration and Air Conditioning Engineers recognized this unique approach with an award to Ontario Hydro for the design of energy efficient buildings.

Costs and Benefits

Though this project resulted in specific quantifiable benefits for the restaurant, the real benefit was in the demonstration of the potential of this technology for energy conservation and demand management. These benefits though large are difficult to quantify.

ARCED GAS ANALYZER
(Expected Benefit)

Research Result

A novel low-cost SF_6 arcing by-product detector has been developed in the Research Division. Several are now being used in the field. Commercialization by an external company is underway.

Background

Ontario Hydro currently has 7 substations insulated with gaseous SF_6. This gas does not age or degrade in normal electric fields, however, a flashover or arc may decompose it and produce toxic, corrosive by-products. Research into the effects of these by-products has led to the development of an instrument (Arced Gas Analyzer) which can be used in the field to quickly measure by-product concentrations in order to determine where a fault has occurred. At least two days time can be saved in fault location by using this equipment. Once the contaminated SF_6 gas has been removed from the substation, it may be cleaned through a scrubber system. The gas analyzer becomes useful once again to ensure that all of the by-product has been removed so that the gas may be reused.

Costs and Benefits

The present value of the research and development costs for investigating the effects of arc by-products in an SF_6 substation is 550 k$ which includes 50 k$ for development of the arc gas analyzer.

The net present value of the benefit achieved from 1985 to 1995 is 2.6 M$. These figures are based on an assumption of 3 outages per year from 1985 to 1988, and 2 outages per year from 1989 to 1995. This gives a net benefit to cost ratio of nearly 5.

Though not included in the above calculations, it should be noted that there are also substantial financial benefits in preventing damage to the switchgear by finding faults quickly. Additional financial benefits may accrue since this analyzer has been licensed for use by commercial companies. The added margin of safety from its use in establishment of handling and clean-up procedures after a fault for maximum worker protection from the toxic substance is also a consideration.

FALL PROTECTION DEVELOPMENT
(Benefit Difficult to Quantify)

Research Result

The Research Division in collaboration with the Transmission Operations Division have continued the development and improvement of fall protection systems.

Background

This project is a part of the Corporate effort to substantially improve the level of fall protection offered to workers in all of its operations. Several new fall protection systems have been developed for various types of movements required when working on transmission towers. To this date (February '89) the Transmission Operations Division has enjoyed 75 months of work without a fatality or permanent disability due to falls. Ontario Hydro has at the present time the best fall protection among all North American electric utilities.

Benefit

The avoidance of the loss of life and lowering of the injury severity in falling accidents is a gratifying benefit to report. Paradoxically it is difficult to assign a monetary value to it. For that reason this project is categorized as having a benefit difficult to quantify.

PORCELAIN INSULATOR FAILURE MECHANISM
(Benefit Difficult to Quantify)

Research Result

In the 1970's a trend of increasing outage rates on transmission lines was noticed. An investigation was undertaken by the Research Division and revealed that many of the porcelain suspension insulators were failing as a result of cement growth.

Background

During the late 1950's when insulator failure rates were very low routine testing of insulators on transmission lines was discontinued. Increased outage rates in the 1970's prompted an investigation by the Research Division which revealed that cement growth was a significant factor in many porcelain insulator failures.

As a result, purchase specifications have been modified and replacement programs have been initiated for both the transmission and distribution systems.

Benefit

The benefits include a reduced outage rate and improved safety. Though the benefits are substantial they are difficult to quantify.

INVESTIGATION OF PORTABLE GAS DETECTORS
(Benefit Difficult to Quantify)

Research Result

Though many models of portable, direct-reading, multiple gas monitors are available, no Canadian Standards Association guidelines exist for their performance. In response to concerns voiced by the municipal electric utilities of Ontario, the Canadian Electrical Association (CEA) commissioned the Research Division to investigate the operating characteristics of these instruments.

Background

Portable gas monitors are important tools for Ontario utility workers. The Ontario Occupational Hazard and Safety Act of 1978 designates the electrical utility manhole as a confined space and further specifies that while a worker is in a confined space the area be either continuously ventilated or continuously monitored for oxygen deficiency, explosive gases and toxic gases.

Prior to the Research Division program there was no reliable catalogue of the operating characteristics or the performance levels of these instruments. In November of 1984 the Research Division undertook a program to examine nine aspects of instrument operation. These aspects were instrument calibration, instrument stability, interference, humidity effects, temperature effects, vibration sensitivity, radio frequency interference, instrument design, and instrument manuals and servicing. This work received funding from the CEA and the Association of Municipal Electric Utilities of Ontario as well as receiving internal funding. The test results were published in a CEA report in December of 1985.

Benefit

The availability of a comprehensive listing of operating characteristics reduces the risk of accidents due to improper instrument use. In addition the existence of such a list provides a basis for the formal establishment of guidelines for the design and use of these instruments.

BURNER ASSISTED HEAT PUMP
(Benefit Difficult to Quantify)

Research Result

A burner assisted heat pump invented by an Ontario company was brought to Ontario Hydro's attention. Personnel of the Research Division evaluated it in various conditions simulated in the laboratory and suggested some modifications and improvements. Field trials verified the performance of the improved models.

The device has the potential of reducing the peak heating load in Ontario by 60 MW.

Background

The burner assisted heat pump operates as a central air-conditioner in the summer. In the winter it operates for part of its cycle as an air source heat pump and for part of its cycle as a condensing gas furnace. However, burning takes place entirely outside the building in the heat pump's outdoor unit; only the heat is transferred indoors. Defrosting is achieved through the use of a gas burn rather than a reversing of the heat pump and the stresses inherent in reversing are avoided with a consequent enhancement of heat pump life. Since no resistance heating is employed, installations seldom require more than a 100 Amp service.

The Research Division has been involved in evaluating the device under various conditions simulated in the laboratory and in establishing its "winter load signature" performance. Because of the Division's background and experience in working with high efficiency cold climate heat pumps the personnel involved were able to suggest several modifications and improvements.

Benefits

This project will result in significant monetary benefits to Hydro in terms of avoided peak load and to the buyers of the device in terms of reduced heating costs. Though the major credit for these benefits should go to the company that developed the heat pump, the contribution of the Research Division was significant. The exact monetary benefit is difficult to quantify.

In addition a good citizenship aspect of the Corporation is illustrated by its technical assistance to a small Ontario company that has grown to become a "high tech" exporter.

CONTAINMENT LEAK LOCATION
(Benefit Difficult to Quantify)

Research Result

Increasing emphasis is being placed on maintaining the containment integrity of nuclear units. A package of techniques developed in the Research Division promises to substantially speed up the location of leaks and the assessment of their significance.

Background

The method traditionally used for location of leaks in the containment boundary involves spreading detergent on the exterior while the interior is pressurized. Bubble formation occurs at the leak location. Because of the vast areas to be searched and the possibility of leakage from containment via penetrating subsystems, the bubble method can only be applied to a small fraction of possible leak sites. The method is time consuming and involves exposing personnel both to hazardous work conditions and radiation.

New leak detection methods devised at the Research Division include a directional acoustic detector sensitive to ultrasonic noise generated by the leak, and a tracer gas technique whereby air samples are collected external to the pressurized containment envelope and analyzed by gas chromatography for the presence of an ethylene tracer previously injected into containment. To determine the magnitude of leakage from an identified leak site and hence its contribution to total building leakage, a mass flow analysis technique and apparatus were developed to catch and measure leakage from sites on various types of building surfaces. These methods were successfully field tested during pressure tests at Bruce NGS A and B (1987 and 1988, respectively) and resulted in greatly reduced labour and time required both to locate leakage and to assess the importance of the leak site. Thus a more complete leak search is possible within the time constraints of the pressure test. Furthermore, the tracer technique permits detection of unsuspected leaks, such as problems in containment isolation, and reduces exposure to radiation fields when searching for leaks in confinement areas adjoining containment.

Benefit

The use of the new package of location techniques could substantially reduce unit outage due to significant containment leakage as well as reducing risk to personnel involved. Though the monetary benefit is expected to be large, uncertainty in the nature and frequency of significant leaks in the future make it difficult to quantify.

FAULT ARC DIVERTER
(Benefit Difficult to Quantify)

Research Result

As an alternative to conventional fuses, a safe effective fault arc diverter for pad-mounted transformers has been developed in the Research Division. The device is the size of a coffee cup and is mounted external to the transformer.

Background

Laboratory tests and field experience indicated potential safety problems with the current-limiting fuses presently installed in dry-well canisters within pad-mounted transformers. Early in 1983 a project was undertaken, with the sponsorship of the Canadian Electrical Association, to develop a small shorting switch attached to the outside of the transformer with the purpose of rapidly diverting current from a failed transformer, thus averting any danger of tank rupture and related hazards.

Such a device has been developed and successfully tested. The system fault is safely cleared subsequent to the operation of the diverter by remotely located fuses or breakers.

An agreement covering the commercialization of this device has been signed with the Amerace Corporation and it will be marketed in 1990 or 1991.

Benefit

The primary benefit of this project is that it successfully addresses a safety problem of concern to Ontario Hydro as well as to the Municipal Electric Association and the electric utility industry in general. In addition to this benefit Ontario Hydro has a royalty agreement with the manufacturer. The potential market for these devices is quite large but since both the new installation rate and the replacement rate are difficult to estimate this monetary benefit is difficult to quantify.

INDUSTRIAL CUSTOMER ASSISTANCE
(Benefit Difficult to Quantify)

Research Result

The process applications unit, through its laboratory, plays the role of facilitator, consultant, researcher and developer in a number of technical fields (including microwaves, radio-frequency, infrared, ultraviolet, and dehumidification) and provides regular support to over 40 industrial marketing representatives located in the regions.

Background

The process applications laboratory was established in 1984 to assist Ontario industries in understanding the benefits of using electrotechnologies. This has been a highly successful effort that is receiving continued support from Ontario Hydro's Marketing Branch. Over the past three years 120 Ontario companies have benefited from proof-of-concept tests carried out in the laboratory. Manufacturers have gained information on how to run their operations with more energy efficiency and have been helped in making investment decisions concerning innovative energy use. In some cases major changes to production methods have been recommended.

Benefits

A review of past projects indicates that 35 companies will implement changes recommended by the process application team. Economic assessment of just nine of the implemented projects reveal estimated benefits of about 1.0 M$ per year. These benefits of course accrue to the economy of Ontario rather to Ontario Hydro directly.

The direct benefits to Ontario Hydro include furthering the wise use of electricity and continuing the Corporation's role as a good corporate citizen.